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THE UNIVERSITY OF MICHIGAN
DEPARTMENT OF ATMOSPHERIC, OCEANIC, AND SPACE SCIENCE

Space Physics Research Laboratory
2245 Hayward Street
Ann Arbor, Michigan 48109-2143

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Report Author(s): J.U. Kozyra

Author(s) Phone: 313/747-3350

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Project Director:
Principal Investigator(s): J.U. Kozyra

Program Technical Officer: Mr. Gilbert D. Bullock
Code 602
Orbiting Satellites Project
Space Science Directorate
NASA/Goddard Space Flight Center
Greenbelt, Maryland 20771

AMPTE Guest Investigator Program
Grant NAG 5-1542, Ring Current Energy Transfer to the Thermal Plasma

Principle Investigator: J. U. Kozyra.

Final Technical Report Covering the Period 5/1/91 through 4/30/94

This document is a final report on research activities and accomplishments carried out with full or partial support from NASA grant #NAG 5-1542 during the funding period of 5-1-91 through 4-30-93, and the no-cost extension that covered the period 5-1-93 through 4-30-94. The no-cost extension was requested to permit publication of final results and attendance at the last few AMPTE CCE team meetings. The focus of our guest investigator program was to bring together, for the first time, critical new knowledge of the energetic particle environment afforded by the AMPTE CCE mission with theoretical investigations of processes coupling inner magnetospheric energy reservoirs to lower altitude region. The transport of energy through the inner magnetosphere and into the underlying ionospheric regions is an important element in our understanding of the impact of solar and magnetic disturbances on upper atmospheric and ionospheric regions equatorward of the auroral zone. The improved knowledge of the inner magnetospheric particle environment, provided by the AMPTE CCE mission, allowed qualitative modeling of energy losses from the ring current and corresponding energy inputs to the lower atmosphere where previously these inputs were estimated.

Major Scientific Accomplishments Fully or Partially Supported Under Grant #NAG 5-472.

- A large-scale simulation of the ring current-plasmasphere interaction during a moderate magnetic storm using boundary and initial conditions from the AMPTE/CCE spacecraft and a dynamical plasmasphere model resulted in new insights into the physics of the coupling in this region [*Fok et al.*, 1993]. Major new results of this study, included:
  (1) The first simulation of the temporal evolution of thermal electron heating rates associated with the Coulomb drag erosion of the ring current, capable of powering an observable SAR arc over a ten-hour lifetime. Electron heating rates reach values sufficient to support a SAR-arc with an intensity of several 100 R, with a lifetime of some 10 hours. This predicted magnitude and lifetime of the SAR arc is consistent with observational information.
  (3) The build up of suprathermal ion populations in the outer plasmasphere that depends strongly on the ring current composition and energy characteristics. A lower energy (10's of eV to keV) ion population builds up during the recovery phase as the higher energy (~10's - 100's of keV) ring current ion population degrades in energy during Coulomb collisions with plasmaspheric electrons. The global features of the build-up and the decay of suprathermal ions are presented in *Fok et al.*, [1993]. The temporal history of the suprathermal population depends both on the species and on the characteristic energy of the parent ring current population. Suprathermal O^+ ions build up with the longest characteristic time scale. Significant suprathermal O^+ is still present a full 2 days into the recovery phase of the

storm. A suprathermal ion population with characteristics similar to the suprathermal distributions predicted by the model, for moderate storm conditions, has been observed [*Lennartsson and Sharp*, 1982; *Shelley et al.*, 1985], but has not been previously attributed to a ring current decay source.

(2) Two-stage thermal ion heating that has a complicated dependence on the level of magnetic activity. Thermal ion heating by the ring current ions is a two-stage process; a low-energy ion population is first formed as a result of Coulomb collisions with plasmaspheric electrons and then this population transfers an increasing fraction of its energy to the thermal ions as it degrades further in energy. The ion heating rate has a very different temporal history than the electron heating rates derived from ring current Coulomb drag energy loss. The relationship between enhanced ion temperatures and magnetic activity is a complex one; no clear understanding of the variation of ion temperatures with increasing magnetic activity has yet been achieved through a combination of theoretical and observational studies. The temporal evolution of the ion heating, predicted by the ring current drift/loss model, is a complicated function of the history of the ring current ion decay and is not simply related to Dst or other global magnetic activity indices. In addition, the heating of the thermal electrons and ions by the ring current as a result of Coulomb collisions may lead to hotter ion that electron temperatures in the outer plasmasphere and a very different temporal history for thermal ion and thermal electron heating during the recovery phase of a magnetic storm.

- An interesting and previously unknown connection was found between ring current nose events and intensifications of SAR arc emissions in the storm main phase [*Kozyra et al.*, 1993]. Energetic particle measurements from the DE-1 and AMPTE spacecraft, on field lines that map to the SAR arc position at low altitude, revealed that an enhancement of the 15-25 keV H^+ component of the ring current, during the main phase of the September 19, 1984 magnetic storm, was responsible for an approximately order of magnitude increase in the electron heating rate and SAR arc emissions during the main phase compared to the recovery phase. In agreement with previous work, ring current O^+ supplied the bulk of the electron heating during storm recovery phase. The early main phase enhancement in this relatively low-energy H^+ flux occurred in association with a ring current "nose event", a front of ions injected into the inner magnetosphere in response to a discontinuous change in the cross-tail electric field (c.f., *Ejiri et al.* [1980]). The association between nose events and intensifications of SAR arc emissions in the main phase has not previously been explored, but is a natural consequence of the injection of significant fluxes of relatively low energy ring current ions earthward of the plasmapause during early storm-time ring current formation. These observations raise the interesting possibility that information regarding early ring current development might be extracted from SAR-arc intensifications during the storm main phase, observed by ground-based optical instruments.

- A large-scale simulation of the ring current-plasmasphere interaction during a major magnetic storm using boundary and initial conditions from the AMPTE/CCE spacecraft and a dynamical plasmasphere model resulted in new insights into the importance of precipitation losses for producing the two-stage decay typical of these large magnetic disturbances [*Fok et al.*, 1994].

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